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TECHNICAL REPORT 2179

CHARACTERISTICS OF EXPLOSIVE SUBSTANCES FOR APPLICATION IN AMMUNITION

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SAMUEL FELTMAN AMMUNITION LABORATORIES
PICATINNY ARSENAL
DOVER, N. J.

ORDNANCE PROJECT TA3-5002
DEPT. OF THE ARMY PROJECT 504-01-011

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CHARACTERISTICS OF EXPLOSIVE SUBSTANCES FOR APPLICATION IN AMMUNITION

by

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Picatinny Arsenal
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Approved:

for I. O. DREWRY
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Director,
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Ammunition Laboratories

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OBJECT

To record experimental data obtained on the properties of new and standard explosive compounds and compositions.

ABSTRACT

This project was established to provide for the testing and evaluation of new explosives synthesized in this Laboratory or on contract. During the past two years, the following materials were characterized: dinitrobenzfuroxan (DNBF), cesium DNBF, potassium DNBF, rubidium DNBF, mercuric DNBF, silver DNBF, lead DNBF; copper chlorotetrazole; stannous methylene bis (nitroso hydroxylamine) (i.e., stannous MEDNA), cupric MEDNA, lead MEDNA, mercury MEDNA, calcium MEDNA, cadmium MEDNA, barium MEDNA, and thallium MEDNA; lead nitrate-bis basic-4,6-dinitro-ortho-cresylate monohydrate; tris (ethylenediamine) chromic perchlorate; cyclotrimethylene-trinitrosamine (R salt); 2,4,6 trinitrotolyl 3 methylnitramine; cuprous thiocyanate, cuprous thiocyanate (29.1%) + potassium chlorate (70.9%); silver thiocyanate, silver thiocyanate (39.8%) + potassium chlorate (60.2%); lead thiocyanate, lead thiocyanate (53.5%) + potassium chlorate (46.5%); and silver cyanamide.

As a comparison, several specification grade military explosives were retested. These were: mercury fulminate; normal lead styphnate; lead azide; diazodinitrophenol; PETN; tetracene; Cyclonite; Haleite; TNT; Composition A-3; and tetryl. Some effort has also been devoted to the improvement of small-scale laboratory tests. The evaluation tests considered standard at this Arsenal for characterizing initiating type explosives left much to be desired. A need existed for a means of measuring properties such as the ignition time, burning time, linear length of the flame, ignition temperature, and shock wave impulse. This study is being continued to develop better techniques for measuring the properties of initiating materials, under Project TA3-5101, in an effort to obtain ideal explosives for optimum explosive trains.

To determine the above physical properties, two new instruments were developed, a squib tester, and an ignition temperature apparatus.

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INTRODUCTION

1. This report presents the data obtained in the characterization of explosives which have been synthesized under projects controlled by this laboratory or have appeared promising for application in ammunition. Many tests accepted as standard at Picatinny Arsenal were used in this work. However, these tests were not sufficient to determine the possible military use of new primary explosives. Therefore, part of the work of this project was devoted to the development of a squib tester and an ignition temperature apparatus to permit the measuring of such properties as: ignition temperature, ignition time, duration of flame, linear length of flame, and shock wave impulse. In addition, the characteristics of the particles of explosive were obtained by photmicrographic techniques.

DISCUSSION

2. The compounds which were evaluated more fully are mercury fulminate, dextrinated lead azide, normal lead styphnate, diazodinitrophenol, Cyclonite, Haleite, PETN, Composition A-3, tetryl, and tetracene. The recently prepared compounds which were evaluated are: silver cyanamide, several metal salts of methylene-bis (nitroso hydroxylamine), dinitrobenzfuroxan (DNBF) and various salts, copper chlorotetrazole, and a few of the metal salts of thiocyanic acid, by itself, and in combination with potassium chlorate. (Tables 1-5).

3. Included in the evaluation are tests for impact sensitivity, explosion temperature, heat stability, hygroscopcity, water solubility, heats of explosion and combustion, gas volume, crystal density, crystal size and color, brisance, friction sensitivity, specific heat, power, plate dent test, and rate of detonation.

4. Coincident with the evaluation new compounds, work was started on the development of new small-scale tests to make possible a more complete evaluation of the explosives. Since a number of the new compounds were expected to be used as primary explosives, it was decided to study the characteristics of the flame emitted by the burning explosive. The Instrumentation Unit of Picatinny Arsenal designed and constructed a firing device (Fig 1) which enables the operator to control

the current input through the wire bridge of a measured resistance, by means of variable controls, from 0 to 2 amperes and to register the resistance of the squib from 0 to 11 ohms. It is also possible to apply a specific current for a definite time interval. Outlets were provided for connecting a chronograph and a photocell which are used in recording ignition time.

5. When the current (I), resistance (R), and ignition time (t) are known, the energy input (E) required to ignite any explosive may be calculated by the formula: $E = I^2Rt\ (10^7)$ where E is expressed in ergs, I in amperes, T in seconds, and R in ohms. This formula was used to determine the energy values reported in Table 6 for ignition of the various explosives in bridge-wire squibs.

6. Since carbon-bridge-type squibs are also used in several fuze designs, tests similar to those made with the wire-bridge-type squibs were run. The firing energies needed for this type of initiation were calculated from the results obtained, and are listed in Table 6 (See also Fig 2).

7. The burning times, or the duration of flame produced in the visible bands of the spectrum, were measured with the equipment shown in Figure 1. The results (Table 6) show that the lead salt of DNBF has the longest visible duration of flame, while the alkali salts do not register on the photocell at all.

8. Although this test gave information on the characteristics of the flame, it was believed that photographs would permit a more comprehensive study of the flame structure. Such pictures were made using a technique similar to that used in obtaining the burning times. In this test the fixture was placed in a dark room in front of a plate camera. The camera shutter was opened before firing and remained open until the squib had been fired.

9. Figures 3,4, and 5 show the flames emitted by several of the compounds and mixtures tested. The normal lead styphnate produces a much larger flame than colloidal normal lead styphnate. Mercury fulminate also produces a large flame, while dextrinated lead azide gives a small spit of flame. (Grouping some of these compounds according to their

use, the FA70 mix is a percussion primer mixture, while the modified 7L and the PA 100 are stab type mixtures.) The results obtained from DNBF salts and silver cyanamide corroborate those obtained from the duration of the flame test. Again, the lead DNBF registered a flame which the alkali salts did not. An interesting observation in the case of the lead DNBF is that the flame emitted was much larger than that of any of the other mono-component explosives.

10. From the results tabulated in Table 6, it can be observed that the addition of an oxidant to an explosive or a fuel in stoichiometric quantities increases the burning rate and decreases burning time. By controlling the amount of added oxygen, from zero percent to stoichiometric amounts, it was believed that the length of the flame could also be controlled. An attempt to illustrate this is shown in Figure 5. Here, the cesium styphnate alone (B), having a negative oxygen balance, has a flame three times as long as that produced when it is combined with potassium chlorate (C). Since the presence of sufficient oxygen permits a much more rapid rate of burning, the duration of the visible flame is much shorter. It can be observed (Fig 5), that the length of the flame is similarly shorter.

11. In the case of silver cyanamide (D), a fuel, ignition did occur but no visible flame was observed or recorded (See Table 6 and Figure 5-D). By adding potassium chlorate, the flame (Table 6) was made visible to the photocell and was recorded by the camera (Figure 5-E).

12. The shock wave emitted in an open air system, was measured for several compounds (Fig 6). Figure 7 shows the equipment which was used to record the character of the shock wave produced by the explosive when fired in an M1A1 squib and received by a piezoelectric crystal gage at a distance of six inches from the squib being tested. The oscillographs of the resulting shock waves are shown in Figure 6. A comparison of the results shows the potassium DNBF to have a lower peak pressure than the other two alkali salts. These two salts, rubidium and cesium, have peak pressures similar to basic lead styphnate, which is used to initiate lead azide in some low-energy electric-type detonators. It is of interest to note that the lead DNBF which produced such a large flame

did not emit a shock wave sufficiently strong to be recorded.

13. The Fisher sub-sieve sizer was considered too hazardous to be used in determining the particle size of these explosives. Therefore, an alternate method was used in which photomicrographs were taken and the average particle size or crystal size measured by a superimposed scale.

EXPERIMENTAL PROCEDURE

14. The characterization tests used in this work, except for those referred to in detail in this report, are described in Picatinny Arsenal Technical Report 1401 (Revision 1).

15. Those explosives which are described as military explosives have been prepared commercially according to specifications and were given a conformatory analysis before they were used. All new materials investigated for use as explosives were prepared as laboratory samples were of the highest purity possible.

16. The following procedure was used in determining ignition time, burning time, and flame characteristics. The M1A1 squib was filled with a weighed amount of the material to be tested, placed in a mount, connected to the firing leads from the squib tester, and set in front of the photocell in a hood protected from any outside light (See Fig 1). Next the resistance of the bridge was determined with a potentiometer, the desired input current set on the dial, and the squib fired by pressing the firing button on the face of the squib tester. This actuated the chronograph, which was stopped by the resulting flash of the material firing in front of the photocell. The ignition time was read in milliseconds, the chronograph having an accuracy of 0.1 millisecond.

17. A General Electric time interval meter (G. E. catalog No. 5106917) and a phototube preamphifier (G. E. catalog No. 51115576) were used to record the burning times (flame duration) of the compounds tested. The compound to be tested was loaded into an M1A1 squib which was placed 1-1/2 inches away from the phototube in a standard hood protected from the light by a dark curtain (Photo 1). When the resistance was determined, the desired input current set on the dial, and the time interval meter set on open, the

squib was fired. The burning time in milliseconds was then read from the dial. The measured time is the total length of the visible burning time from zero start back to zero finish.

18. The flame characteristics of the compounds were determined by taking photographs of the flames in a darkened walk-in hood. The M1A1 squib was first filled with a definite weight of the material and placed in a clamp in front of a six-inch white ruler held vertically against a black background. A 35 mm camera equipped with a Leica lens was used with the lens fully opened (f/3.5). Kodak Super XX film was used in the camera, which was placed three feet from the squib. The squib was fired using the squib tester set at 600 milliamperes of current.

19. The results obtained for the shock wave tests were picked up with a piezoelectric crystal gage using a barium titanate crystal and recorded by an oscilloscope camera apparatus. The M1A1 squib was first loaded by hand tamping, with a definite weight of material and placed two inches away from and parallel to the face of the piezo crystal gage. This gage was then connected to an oscilloscope (Dumont Model 304H-Serial No. 2399) and the resulting oscillogram photographed on linagraph film.

20. The energy to initiate explosives in carbon-bridge-type detonators was determined using the T18E4 detonator squib assembly. These squibs were fired by passing 110 volts AC through an AC to DC converter, to a variable condenser, and then through the firing leads to the T18E4 holder. An ohmmeter was used to check the resistance of the detonator before firing, and to set the firing voltage. The maximum voltage used was three hundred volts. The variable condenser (Model No. 83595-Central Scientific Co.) has two dials for setting the charge; one ranges from 0.01 to 0.10 mfd and the other from 0.1 to 1.0 mfd. Hence, by keeping the resistance constant and varying the voltage and capacitance, it is possible to control the energy used to initiate the explosive. This energy can be calculated by using the formula $\underline{E}$ $5cv^2$, where $\underline{E}$ is in ergs, C is in microfarads, and v is in volts.

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INCLOSURES

Tables 1-6
Figures 1-13

TABLE 1

Military Explosives Used as or in Primers Compared With New Explosives Having Similar Properties

	Mercury Fulminate	Normal Lead Styphnate	Dinitro-Benz-Furoxan	Cesium DNBF	Potassium DNBF	Rubidium DNBF	Mercuric DNBF	Silver DNBF	Cupric DNBF	Lead DNBF (hydrate)
Impact Sensitivity, P. A. Machine										
2 kg. wt, inches	2[c]	3[c]	9	2	3	3	3	4	4	7
1 lb. wt, inches	3[c]	33	*	6	6	7	14	13	40	32
average chge, wt, grams	0.030[c]	0.021	0.010	0.012	0.007	0.009	0.013	0.10	0.10	0.020
Explosion Temperature, °C	210[c]	282[c]	310	210	250	225	215[a]	200[a]	260	185
100°C Heat Test, % Loss										
1st 48 hrs.	exploded[c]	0.38	0.28	0.08	0.30	0.37	5.20	0.73	9.10	7.05
2nd 48 hrs.	16 hrs	0.73	0.08	0.13	0.05	0.00	2.85	0.20	1.18	0.77
Explosion, 100 hrs.		none	none	none	none	none	none	none	none	none
Hygroscopicity at 30°C, % Gain										
75% R.H.	0.00	0.00	0.14	1.70	0.11	0.62	*	0.28	8.92	*
90% R.H.	0.02	0.02	0.16	3.45	0.27	1.77	*	0.31	4.96	*
Water Solubility at 30°C, gms/100 gm	0.042	0.074	*	0.312	0.245	0.239	0.041	0.284	0.017	0.162
Heat of Explosion, cal/gm	427	457	*	*	725	*	*	698	*	*
Heat of Combustion, cal/gm	938	1251	1790	*	2209	1931	*	1864	1948	*
Gas Volume, cc	243	368	*	*	604	*	*	484	*	*
Particle Size, Microns	554	48	*	*	74	*	*	*	*	*
Color	gray[c]	yellow to brown[c]	golden-brown	yellow-orange	orange to brown	violet	red	brick-red	black	red
Crystal form	rhombic[c]	hexagonal[c]	*	*	platinates	*	*	*	*	*
Absolute Density	4.43[c]	3.08[c]	1.703	*	2.026	2.208	*	2.529	*	*
200 gm Bomb Sand Test - gms. sand crushed when initiated by:										
Black Powder Fuze	23.4[c]	11.4[c]	*	12.4	9.5	7.0	no fire	no fire	no fire	no fire
300 mg. Lead Azide	max w/BPF[c]	24.0[c]	*	35.8	44.8	38.9	0.0	44.1	27.8	25.7
200 mg. Lead Azide + 100 mg Tetryl	max w/BPF[c]	max w/L.A.[c]	*	34.8	43.6	40.0	5.0	57.5	29.7	27.6
Friction Sensitivity										
Fiber Shoe	detonates[c]	detonates	*	**	**	**	**	**	**	*
Steel Shoe	a c		*	**	**	**	**	**	**	*

a. Smoked - no detonation
b. Flashed
c. Work reported previously
* Further work suspended to enable the investigation of the more promising compounds to be completed first.
** Since the friction sensitivity test used at this Arsenal has, as one of its limitations, the fact that the test also reacts to impact sensitivity; those compounds which show a very low impact value are assumed to give a positive test on the friction machine.

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TABLE 1 (Con't) CONFIDENTIAL

Military Explosives Used as or in Primers Compared With New Explosives Having Similar Properties

	Copper Chloro-Tetrazole	Stannous Methylene Bis (Nitroso Hydroxyla-mine)	Cupric MEDNA	Lead MEDNA	Mercury MEDNA	Calcium MEDNA	Cadmium MEDNA	Barium MEDNA	Thallium MEDNA	Lead Nitrate Bis Basic-4,6 Dinitro-Ortho-Cresylate Mono-hydrate
Impact Sensitivity, P. A. Machine										
2 kg. wt, inches	1	1	4	2	2	10	12	15	2	11
1 lb. wt, inches	3	3	42	18	*	*	*	*	10	*
average chgc, wt, grams	0.009	0.015	0.011	0.015	0.021	0.090	0.014	0.016	0.22	0.022
Explosion Temperature, °C	305	385[b]	190[a]	240[b]	165[a]	295a	240[a]	275	225	265
100°C Heat Test, % Loss										
1st 48 hrs.	2.67	0.57	4.35	3.45	34.15	1.92	1.25	10.68	0.18	0.50
2nd 48 hrs.	0.10	2.17	1.23	0.08	2.37	0.00	0.17	0.00	0.00	0.00
Explosion, 100 hrs.	none	none	none	none	none	none	none	none	none	none
Hygroscopicity at 30°C, % Gain										
75% R.H.	*	0.00	2.24	0.00	0.00	0.00	4.87	7.64	0.16	0.26
90% R. H.	3.11	0.00	4.87	0.00	0.00	39.23	5.36	9.58	0.18	0.77
Water Solubility at 30°C, gms/100 gm	0.02	0.02	0.02	0.02	*	*	*	*	0.67	0.23
Heat of Explosion, cal/gm	*	1012	975	612	*	*	*	*	*	*
Heat of Combustion, cal/gm	*	1134	1024	620	*	*	*	*	*	*
Gas Volume, cc	*	243	247	126	*	*	*	*	*	*
Particle Size, Microns	*	*	*	*	*	*	*	*	*	*
Color	blue	cream	blue	buff white	buff-white	white	white	white	white	brown
Crystal form	*	*	*	*	*	*	*	*	*	*
Absolute Density	2.040	2.772	*	*	*	*	*	*	*	*
200 gm Bomb Sand Test - gms. sand crushed when initiated by:										
Black Powder Fuze	17.0	2.1	failed	0.0	failed	*	failed	failed	*	1.2
300 mg. Lead Azide	25.3	27.6	*	20.1	*	*	*	*	*	17.5
200 mg. Lead Azide 100 mg Tetryl	27.4	26.5	*	17.8	*	*	*	*	*	17.1
Friction Sensitivity										
Fiber Shoe	**	**	**	**	**	*	*	**	**	*
Steel Shoe	**	**	**	**	**	*	*		**	*

a. Smoked - no detonation
b. Flashed
c. Work reported previously
* Further work suspended to enable the investigation of the more promising compounds to be completed first.
** Since the friction sensitivity test used at this Arsenal has, as one of its limitations, the fact that the test also reacts to impact sensitivity; those compounds which show a very low impact value are assumed to give a positive test on the friction machine.

TABLE 2

Military Explosives Used As Intermediate Charges And
New Explosives Having Similar Properties

	Lead Azide (dextrinated)	Diazo-Dinitrophenol	PETN	Tetracene	Hexamine Chromic Perchlorate	Tris-Ethylene Chromic Perchlorate
Impact Sensitivity, P. A. Machine						
2 kg. wt, inches	5*	4	6*	2*	8	3
1 lb. wt, inches	23	7	a	a	30	18
average chgc, wt, grams	0.027	0.015	0.016*	0.016*	0.020	0.012
Explosion Temperature, °C	340*	180	225*	160*	350	315
100°C Heat Test, % loss						
1st 48 hrs.	0.34*	2.10*	0.10*	23.2*	0.08	0.35
2nd 48 hrs.	0.05*	2.20*	0.00*	3.4*	0.00	0.00
Explosion, 100 hrs.	none*	none*	none*	none*	none	none
Hygroscopicity at 30°C, % Gain						
75% R.H.	0.00	0.00*	0.00*	0.00	0.02	4.50
90% R.H.	0.48	0.04*	0.00*	0.80*	0.05	26.0
Water Solubility at 30°C, gms/100 gm	0.005	0.040	a	a	b	18.4
Heat of Explosion, cal/gm	342	820*	1370*	664*	1040	**
Heat of Combustion, cal/gm	630	3243	1960*	2758	1110	**
Gas Volume, cc	340	865	a	451	125	**
Particle Size, Microns	554	28	192	546	50	**
Color	gray*	greenish-brown *	white*	pale-yellow*	yellow	yellow
Crystal form	rhombic*	elongated*	needles*	needles*	**	**
Absolute Density	4.68	1.63*	1.77*	a	1.95	**
200 gm Bomb Sand Test - gms. sand crushed when initiated by:						
Black Powder Fuze	23.4	45.6*	0.00	4.0*	32.3	**
300 mg. Lead Azide	max w/BPF	47.5*	62.7*	28.2*	41.8	**
200 mg. Lead Azide + 100 mg Tetryl	"	max w/L.A.*	max w/L.A.*	max w/L.A.*	40.6	**
Friction Sensitivity						
Fiber Shoe	detonates*	detonates	unaffected*	detonates	**	**
Steel Shoe	" *	"	cracks*	"	**	**

a. The future use of this compound at Present seems doubtful and further characterization was not warranted.

b. The sample reacted with the wafer to form a gelatinous precipitated.

* Results obtained by other investigators

** Results not obtained as yet

TABLE 3

Standard Military Explosives Used As Base Charges, Boosters or in Main Charges, And New Explosives Having Similar Properties

	Cyclonite (RDX)	Haleite (EDNA)	TNT	Composition A-3	Tetryl	Cyclotrimethylene Trinitrosamine	2,4,6, Trinitro-Tolyl-3-Methyl-nitramine
Impact Sensitivity, P.A. Machine							
2 kg. wt, inches	8*	14*	14*	16*	8*	8	10
average wt. of charge, grams	0.018*	0.017*	0.017*	0.017*	0.017*	0.010	0.013
Explosion Temperature, °C, 5 secs.	260*	189*	475*	250*	257*	220	235
100°C Heat Test, % Loss							
1st 48 hrs.	0.04*	0.2*	0.2*	0.2*	0.07	8.79	0.55
2nd 48 hrs.	0.00*	0.3*	0.2*	0.2*	0.07	2.98	0.37
Explosion, 100 hrs.	none*	none*	none*	none*	none	none	none
100°C Vacuum Stability Test							
Weight, grams	5.0*	5.0*	5.0*	5.0	5.0*	2.5	2.5
Gas, mls	0.7*	0.5*	0.10*	0.42	0.3*	9.19	1.07
Time, hrs	40*	40*	40*	40	40*	40	40
Water Solubility at 30°C, gms/100 gms	0.005*	0.005	0.0219*	0.90*	0.09	0.28	0.01
Hygroscopicity at 30°C, % Gain at 90% R.H.	0.00	0.01*	0.00*	0.00*	0.04*	0.02	0.07
Heat of Explosion, cal/gm	1280*	981*	1060	**	1130*	876	752
Heat of Combustion, cal/gm	2285*	2477*	3620	1210*	2925*	3158	3323
Gas Volume, cc	**	**	**	**	**	1030	938
Particle size, microns	388	192	**	862	605	6.8	12.5
Color	white*	white*	buff*	white to buff*	yellow*	yellow	buff
Crystal Form	ellipsical*	**	flakes*	ellipsical*	ellipsical*	**	**
Crystal Density or Specific Gravity	1.82*	1.71*	1.65*	**	1.73*	2.14	1.64
200 gm Bomb Sand Test - gms of sand crushed when initiated by:							
Black Powder Fuze	0.00*	0.00*	0.00*	0.00*	0.00*	0.00	0.00
300 mg Lead Azide	60.2*	52.3*	48.3*	51.5*	54.2*	59.2	55.0
200 mg Lead Azide + 100 mg Tetryl	max w/L.A.*	max w/L.A.*	max w/L.A.	max w/L.A.*	max w/L.A.*	54.1	49.0
Friction Sensitivity							
Fiber Shoe	unaffected*	unaffected*	unaffected*	unaffected*	unaffected*	unaffected	unaffected
Steel Shoe	exploded*	unaffected*	unaffected*	unaffected*	crackles*	unaffected	crackles
Ballistic Mortar (TNT = 100)							
Power	150*	139*	100*	135*	130*	130	113
No. of Trials	100 *	34*	standard	11*	51*	8	11
Plate Dent Test							
Method	A*	A*	A*	B*	A*	**	**
Condition	pressed*	pressed*	pressed*	pressed*	pressed*	**	**
Confinement	yes*	yes*	yes*	no*	yes*	**	**
Density, gms/cc	1.50*	1.50*	1.50*	1.61*	1.50*	**	**
Brisance, % (TNT = 100)	1.35*	122*	100*	126*	116*	**	**
Rate of Detonation							
meters/second (av. of 10 trys)	8795*	8820*	7187*	8200*	7972*	7055[a]	6580
Density, gms/sec.	1.82*	1.71*	1.65*	1.61*	1.73*	1.48	1.49

a. **Difficulty in going high order; this result is not considered final**
* **Data previously reported by other investigators**
** Information not available yet

TABLE 4

Fuels, And Fuel-Oxidant Mixtures to Replace T61 Primer Mix

Compound	Explosion Temperature, °C (5 secs) Sample 10 mg	Heat Test 100°C, % Loss 1st 48 Hrs	2nd 48 Hrs	Expl. 100 Hrs	Vacuum Stability Test, 100°C Wt, gms	Gas, mls	Hrs No. Expl	Impact Sensitivity P.A. Machine 2 Kg Wt, inch	Wt. of Charge, gms	4 oz Wt, inch	Wt. of Charge, gms	Hygroscopicity 30 C, % Gain 75% R.H.	90% R.H.	Analysis % Metal Found	Theor.
Cuprous Thiocyanate	None	0.44	0.03	None	1.0	0.17	40	None	0.012	None	0.013	-	-	51.8	52.3
Cuprous Thiocyanate (29.1%) + Potassium Chlorate (70.9%)	240°	0.13	0.02	None	1.0	0.41	40	1	0.013	15	0.012	0.06 constant wt. after 400 hrs.	1.83	-	-
Silver Thiocyanate	None	0.26	0.01	None	1.0	0.97	40	None	0.014	None	0.016	-	-	64.5	65.0
Silver Thiocyanate (39.8%) + Potassium Chlorate (60.2%)	200°	0.11	0.01	None	1.0	0.43	40	1	0.015	14	0.017	0.01	0.00	-	-
Lead Thiocyanate	None	0.18	0.01	None	1.0	0.44	40	None	0.015	None	0.015	-	-	63.9	64.1
Lead Thiocyanate (53.5%) + Potassium Chlorate (46.5%)	205°	0.06	0.01	None	1.0	0.27	40	1	0.016	13	0.014	0.02	0.001	-	-
Silver Cyanamide	245	0.18	0.00	None	-	-	-	40d	0.019	62[a]	0.018	0.35	0.35	84.3	84.3

[a] One pound weight

TABLE 5

Ignition Temperature of Explosive Compounds*

	Point of Immediate Ignition, °C	Lowest Point of Ignition	
		°C	Time in Seconds
Potassium Dintirobenzfuroxan	267	240	9.8
Basic Lead Styphnate	312	291	17.5
Copper Chlorotetrazole	348	312	4.2

* Ref.
PATR 2093, Nov 1954

TABLE 6

Behavior of Standard and Experimental Primary
Explosives in Items Electrically Initiated

		Mercury Fulminate				Normal Lead Styphnate			
	Test No.	1	2	3	4	1	2	3	4
M1A1 Squib	Weight - Mgms.	50	50	50	50	65	65	65	65
	Resistance - Ohms	1.07	1.05	1.05	1.07	1.14	1.12	0.98	1.08
	Current - Mamps	350	400	500	600	400	500	600	700
	Delay Time - Msecs	75.95	35.36	19.16	13.50	34.02	15.05	11.09	8.90
	Flame Duration - Msecs	19	20	22	21	4.4	5.5	6.0	4.8
	Energy - Ergs	96,300	59,500	50,400	52,050	62,000	42,300	39,200	47,100
	Test No.	1	2			1	2		
T18E4 Carbon Bridge	Volts	300	300			40	50		
	Condenser - Mfd.	.01	1.1			.01	.01		
	Resistance - Ohms	2600	3400			2500	1500		
	Energy - Ergs	0.0	0.0			0.0	125		
	Remarks	No Fire	No Fire			No Fire	Fired		

		Hexamine Chromic Perchlorate				Rubidium Dinitrobenzofuroxan			
	Test No.	1	2	3	4	1	2	3	4
M1A1 Squib	Weight - Mgms.	20.0	20.0	20.0	20.0	10	10	10	10
	Resistance - Ohms	1.08	1.07	1.02	1.07	1.06	1.01	1.03	1.08
	Current - Mamps.	500	550	700	900	300	550	600	900
	Delay Time - Msecs.	37.29	33.11	18.22	15.81	68.27	6.90	5.75	2.68
	Flame Duration - Msecs	100+	30	34	42	No Flash	No Flash	No Flash	No Flash
	Energy - Ergs.	100,900	85,500	91,000	137,000	65,200	21,000	21,300	23,400
	Test No.	1	2	3		1	2	3	
T18E4 Carbon Bridge	Volts	300	300	300		50	100	300	
	Condenser - Mfd.	.01	1.1	1.1		.01	.01	.01	
	Resistance - Ohms	6000	5800	5800		1200	2400	2900	
	Energy - Ergs.	0.0	0.0	495,000		0.0	5.0	450	
	Remarks	No Fire	No Fire	Fired with 10,000 psi		No Fire	Fired at 12,000 psi	Violent	

TABLE 6 (Con't)

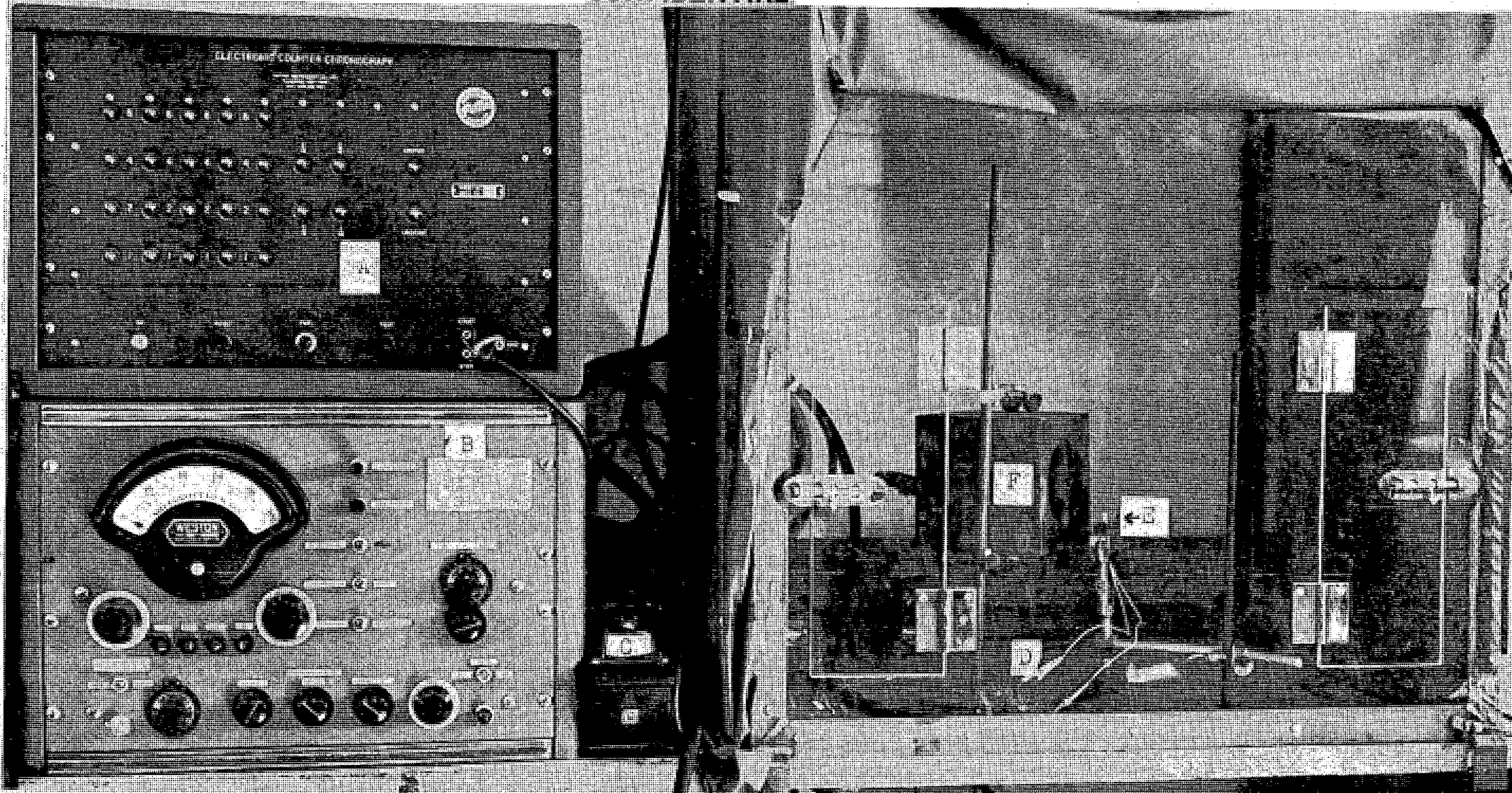
		Diazodinitrophenol				Lead Azide		Silver Cyanamide		
	Test No.	1	2	3	4	1	2	1	2	
M1A1 Squib	Weight - Mgms.	25	25	25	25	No Fire	No Fire	50	50	
	Resistance - Ohms	1.07	1.00	1.02	1.07	No Fire	No Fire	1.02	1.02	
	Current - Mamps	250	300	400	500	No Fire	No Fire	600	540	
	Delay Time - Msecs	435.3	158.07	23.74	11.84	No Fire	No Fire		15	
	Flame Duration - Msecs	26	28	24	24	No Fire	No Fire			
	Energy - Ergs	291,000	142,000	38,600	31,500	No Fire	No Fire	Fired	57,654	
	Test No.	1	2			1	2	1	2	3
T18E4 Carbon Bridge	Volts	300	300			40	50	300	300	300
	Condenser - Mfd.	.01	.1			.01	.01	.01	1.1	1.1
	Resistance - Ohms	1800	4200			1800	2400	5200	1800	25,000
	Energy - Ergs	0.0	45,000			0.0	125	0.0	4.95×10^5	1.28×10^9
	Remarks	No Fire	Fired			No Fire	Fired	No Fire	Fired	Fired

		Cesium Dinitrobenzofuroxan				Potassium Dinitro-benzofuroxan		Lead Dinitrobenzofuroxan		
	Test No.	1	2	3	4	1	2	1	2	3
M1A1 Squib	Weight - Mgms.	30	30	30	30	16	16	50	50	50
	Resistance - Ohms	1.12	1.07	1.08	1.05	1.1	1.1	0.91	0.97	1.04
	Current - Mamps	300	400	900	1000	300	400	400	550	700
	Delay Time - Msecs.	84.51	12.34	2.14	2.34	N.T.	2.8	248	182	196
	Flame Duration - Msecs	No Flash	No Flash	No Flash	No Flash	Fired	N.T.	82	60	70
	Energy - Ergs.	72,000	20,000	18,700	24,600	N.T.	3,000	361,900	582,000	$1. \times 10^6$
	Test No.	1	2	3		1	2	1	2	3
T18E4 Carbon Bridge	Volts	50	75	75		50	100	300	300	300
	Condenser - Mfd.	.01	.01	.01		.01	.01	.01	1.1	.01
	Resistance - Ohms	1200	2100	2200		2400	2200	2800	2800	2800
	Energy - Ergs.	0.0	28	28		0.0	500	0.0	0.0	450
	Remark	No Fire	Violent	Violent		No Fire	Fired	No Fire	No Fire	Fired, No Expl with 10,000 psi

TABLE 6 (Con't)

		Cuprous Thiocyanate + Potassium Chlorate				Silver Thiocyanate + Potassium Chlorate				Mercuric Thiocyanate + Potassium Chlorate		
	Test No.	1	2	3	4	1	2	3	4	1	2	3
M1A1 Squib	Weight - Mgms.	30	30	30	30	25	25	25	25	25	25	25
	Resistance - Ohms	1.02	1.07	1.02	1.09	1.07	1.07	1.13	1.00	1.09	1.08	1.06
	Current - Mamps	350	400	500	600	300	350	400	500	250	300	400
	Delay Time - Msecs	58	23.23	14.60	11.55	31.5	36.34	24.14	18.95	56.76	24.31	16.04
	Flame Duration - Msecs	100+	0.5	0.5	0.5	31	41	50	25	20	20	15
	Energy - Ergs	72,100	39,700	37,200	45,500	53,800	47,500	43,400	47,500	39,000	23,620	27,300
	Test No.	1	2	3		1	2	3	1	2	3	4
T18E4 Carbon Bridge	Volts	250	300	300		300	300	300	300	100	75	100
	Condenser - Mfd.	.01	.01	.01		.01	0.11	0.11	.01	.01	.01	.01
	Resistance - Ohms	1800	3200	1900		4800	16,000	4800	42,000	18,000	17,000	12,000
	Energy - Ergs	0.0	3500	3500		0.0	49,500	49,500		500	291.5	500
	Remarks	No Fire	Fired	Fired		No Fire	Fired	Fired	Fired	Fired	No Fire	Fired

		Silver DNBF	Cupric DNBF	Mecuric DNBF	Stannous MEDNA		Cupric MEDNA	Lead MEDNA	Mercury MEDNA
	Test No.	1	1	1	1	2	1	1	1
M1A1 Squib	Weight - Mgms.	No Fire	No Fire	No Fire	50	50	No Fire	No Fire	No Fire
	Resistance - Mfd.	No Fire	No Fire	No Fire	1.1	1.1	No Fire	No Fire	No Fire
	Current - Mamps.	No Fire	No Fire	No Fire	350	600	No Fire	No Fire	No Fire
	Delay Time - Msecs.	No Fire	No Fire	No Fire	56.03	37.79	No Fire	No Fire	No Fire
	Flame Duration - Msecs	No Fire	No Fire	No Fire	500+	500+	No Fire	No Fire	No Fire
	Energy - Ergs.		No Fire	No Fire	35,600	72,900	No Fire		No Fire
	Test No.	1			1	2			
T18E4 Carbon Bridge	Volts			No Fire	300	300			
	Condenser - Mfd.	No Fire	No Fire	No Fire	.01	1.15			
	Resistance - Ohms	No Fire	No Fire	No Fire	2400	3200			
	Energy - Ergs.	No Fire	No Fire	No Fire	No Fire	No Fire			
	Remarks	No Fire	No Fire	No Fire					



March 1954 Picatinny Arsenal Ordnance Corps

Fig. 1 Apparatus For Determination of Ignition Time and Burning Time and Firing Energy.

A. Chronograph
B. Squib Tester (Firing Apparatus)
C. Galvanometer
D. **Firing leads**
E. M1 Squib Containing Compound
F. Photo-Electric Eye

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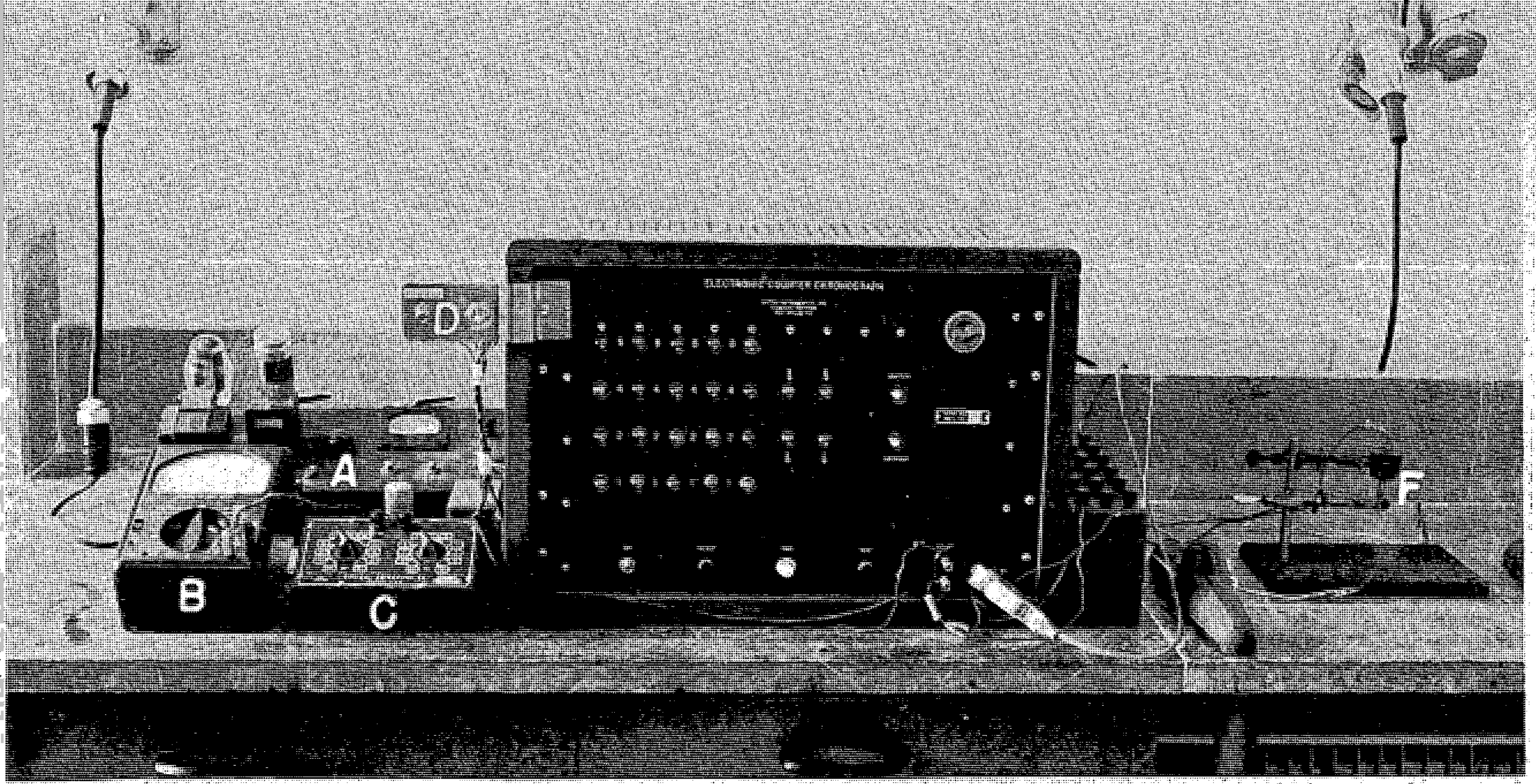

M-40774/2 March 1954 Picatinny Arsenal Ordnance Corps

Apparatus for Determining Ignition Properties of Explosives on Carbon Bridge Detonators

A. AC to DC Converter
B. OHM Meter
C. Variable Condenser
D. Safety Switch and Firing Switch
E. Electronic Counter Chronograph
F. Squib Holder Behind Barricade

Figure 2

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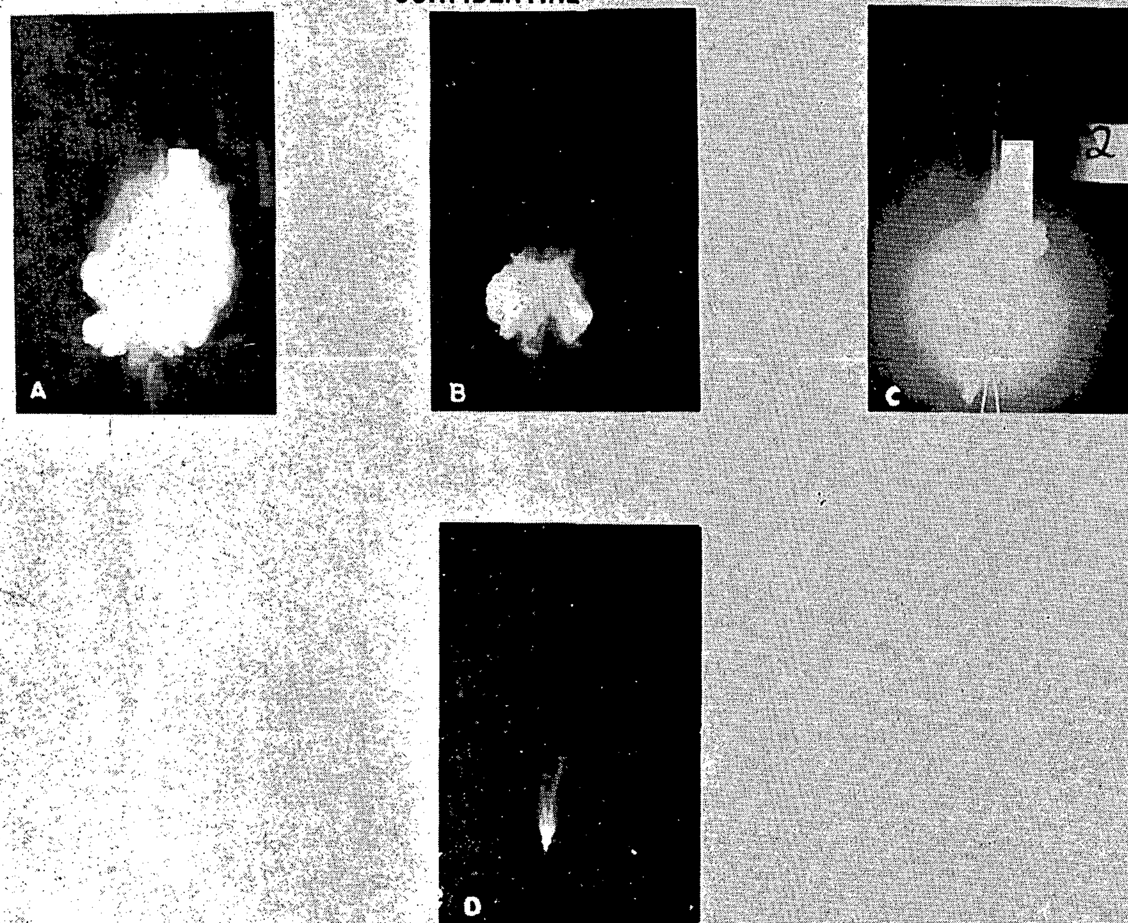


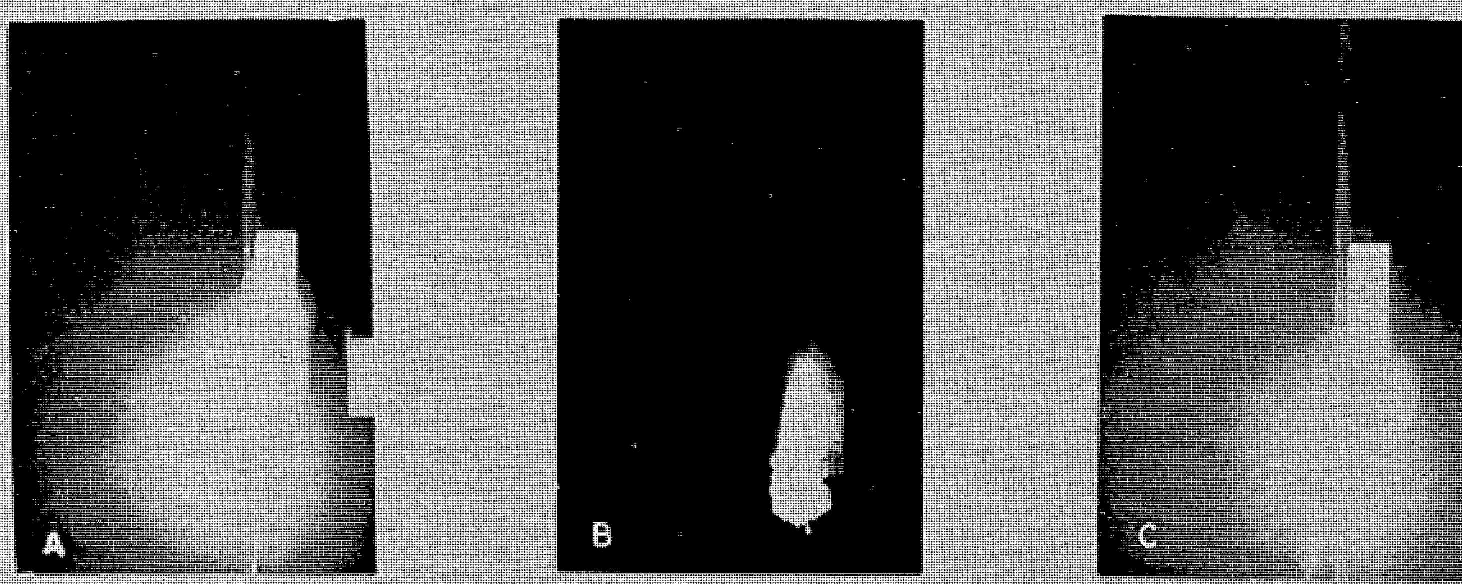
M-42137/1

March 1954 PICATINNY ARSENAL ORDNANCE CORPS

Figure 3

Flame Characteristics of Standard Initiators

A. Normal Lead Styphnate
B. Colloidal Lead Styphnate
C. Mercury Fulminate D. Lead Azide



M-42137/2 March 1954 PICATINNY ARSENAL ORDNANCE CORPS

Flame Characteristics of Standard Primer Mixtures
A. FA 100
B. Modified 7L
C. FA 70

Figure 4

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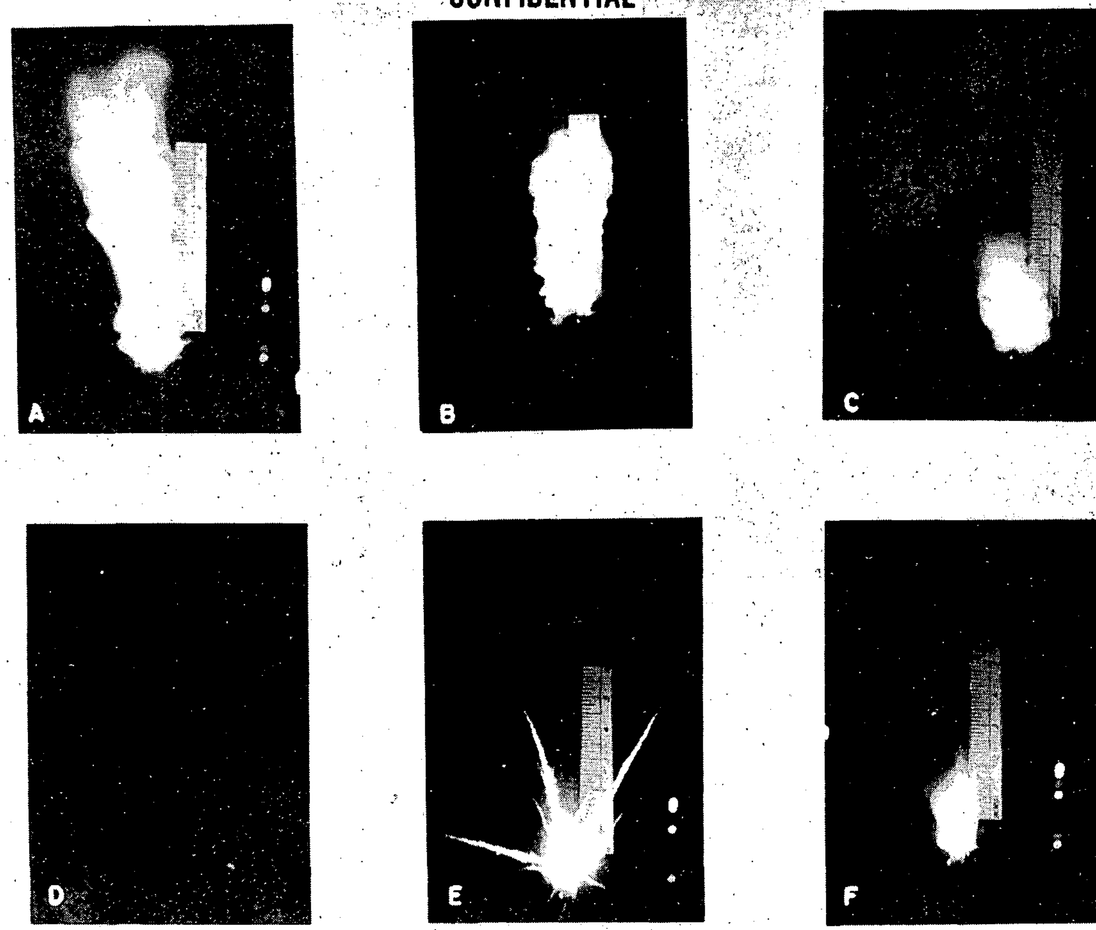

M-42237 March 1954 PICATINNY ARSENAL ORDNANCE CORPS

Flame Characteristics of New Compounds and New Compositions

A. Lead Dinitrobenzfuroxan
B. Cesium Styphnate
C. Cesium Styphnate + $KClO_3$
D. Silver Cyanamid
E. Silver Cyanamid + $KClO_3$
F. Hexamine Chromic Perchlorate

Figure 5

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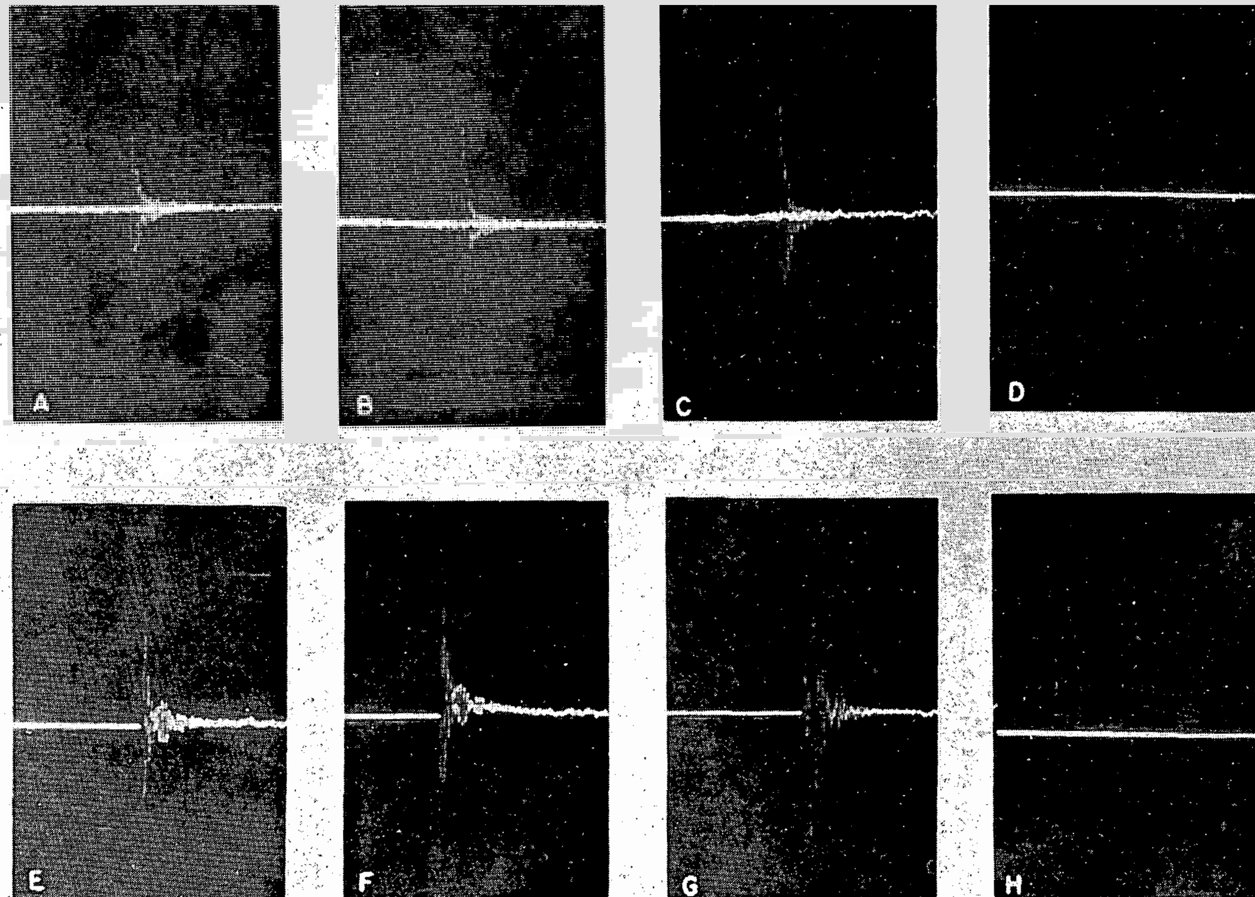

Figure 6

M-42139 March 1954 PICATINNY ARSENAL ORDNANCE CORPS

Comparison of Shock Waves of Standard Primer Mixtures and Metallic Salts of Dinitrobenzfuroxan

A. Potassium Dinitrobenzfuroxan
B. Rubidium "
C. Cesium "
D. Lead "

E. Basic Lead Styphnate
F. NOL 130 Primer (Stab Primer)
G. T61 (Igniter)
H. FA 70 (Percussion Primer).

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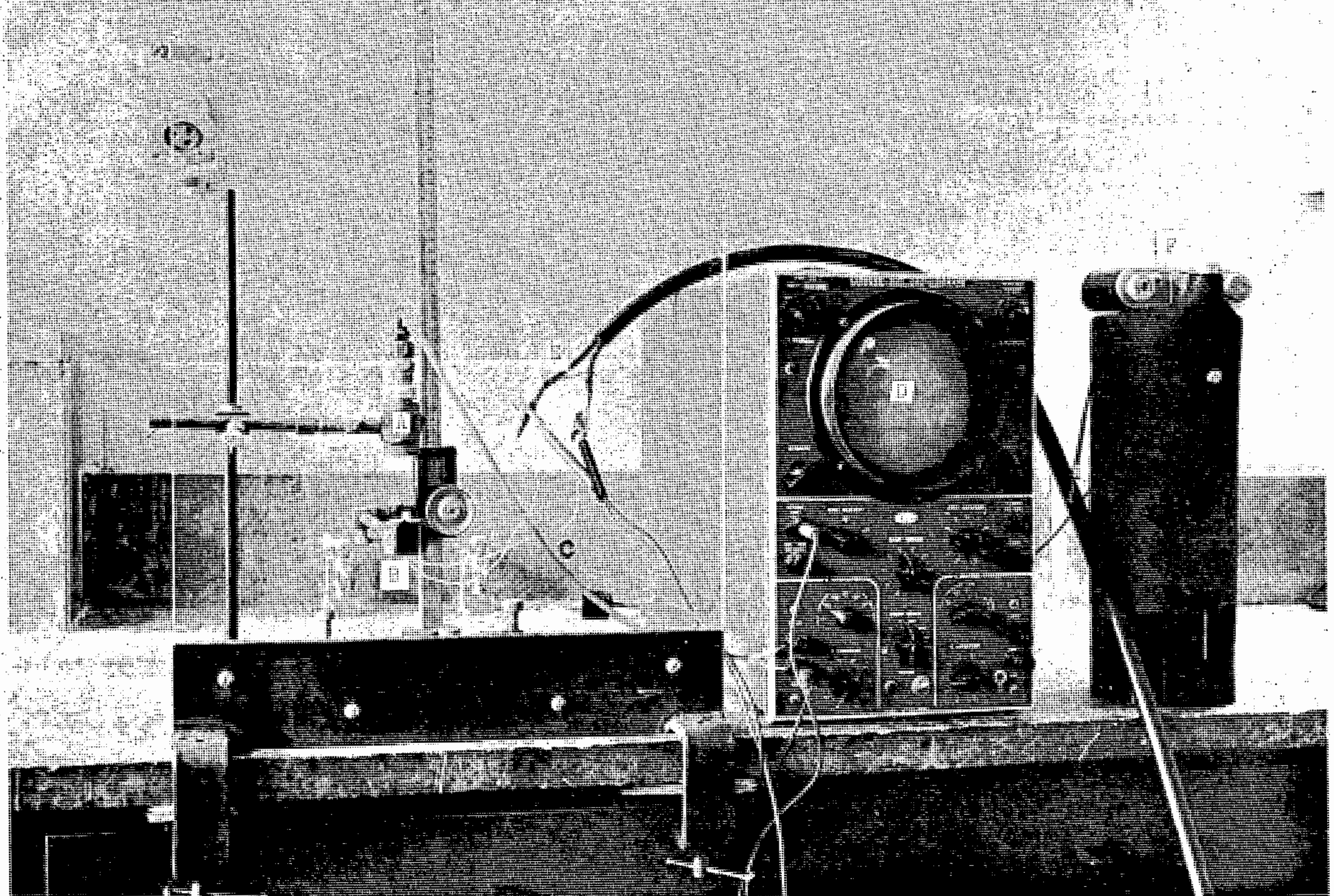

March 1954 Picatinny Arsenal Ordnance Corps

Figure 7
Apparatus For Studying Shock Waves

A. Piezoelectric Pressure Gage
B. M1A1 Electric Squib
C. Lead to Oscilloscope
D. Oscilloscope Model 304"
E. Firing Lead from Squib Tester
F. Oscilloscope Camera

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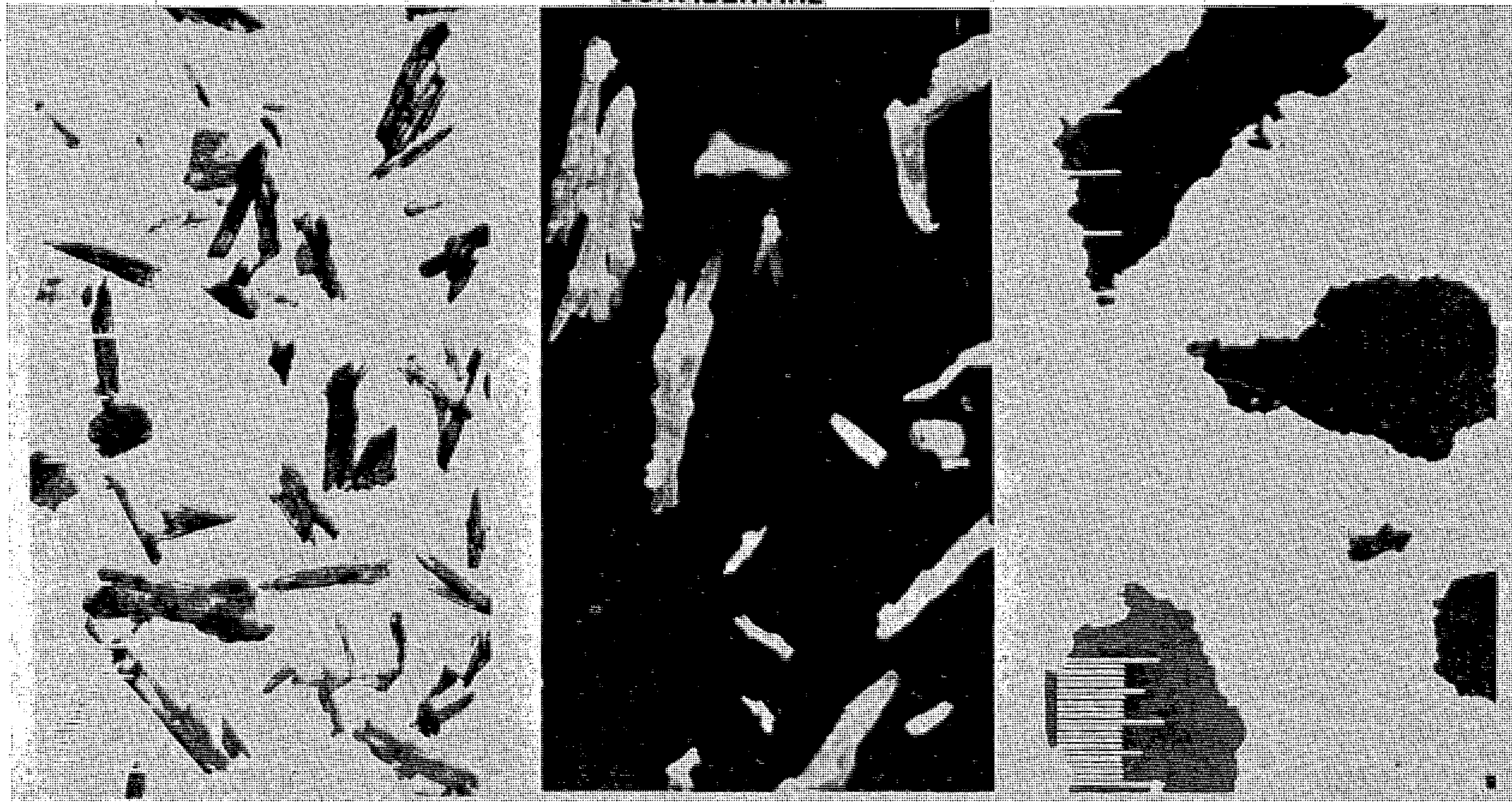

PETN 100x
Average Particle Size: 192 Microns

TETRACENE 130x
Average Particle Size: 190 Microns

SILVER CYANAMIDE 100x
Average Particle Size: Agglomerates

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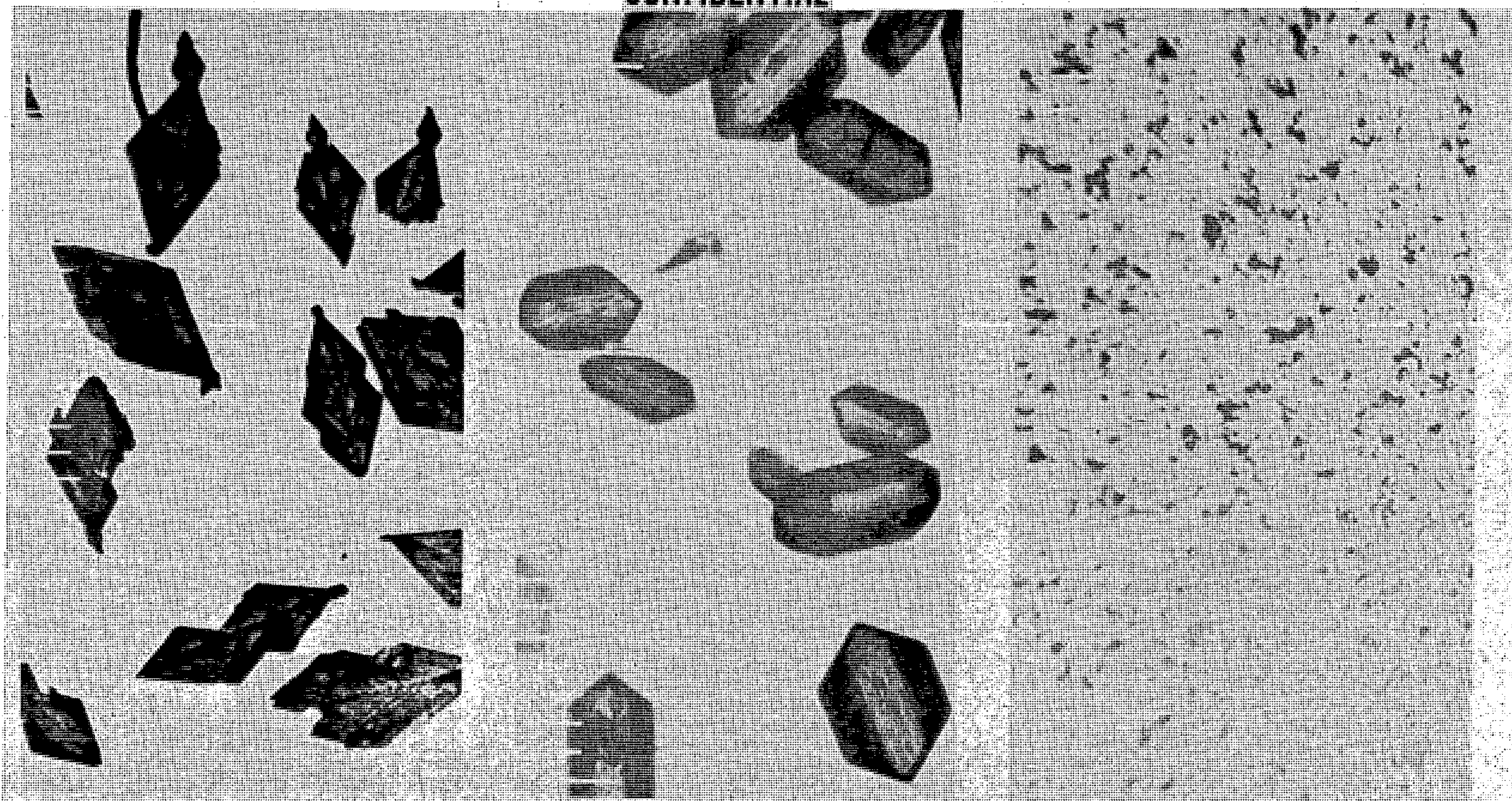
Figure 8

M-42159	March 1955	PICATINNY ARSENAL	ORDNANCE CORPS
Project No. TA3-5002	Prepared by: A. M. Anzalone	Scale: 0.1 mm, 0.01mm.	



MERCURY FULMINATE 40x
Average Particle Size: 554 Microns

NORMAL LEAD STYPHNATE 450x
Average Particle Size: 48 Microns

COLLOIDIAL LEAD STYPHNATE 500x
Average Particle Size: 1 Micron

Figure 9

M-42158	March 1955	PICATINNY ARSENAL	ORDNANCE CORPS
Project No. TA3-5002	Prepared by: A. M. Anzalone		Scale: 0.1 mm, 0.01 mm

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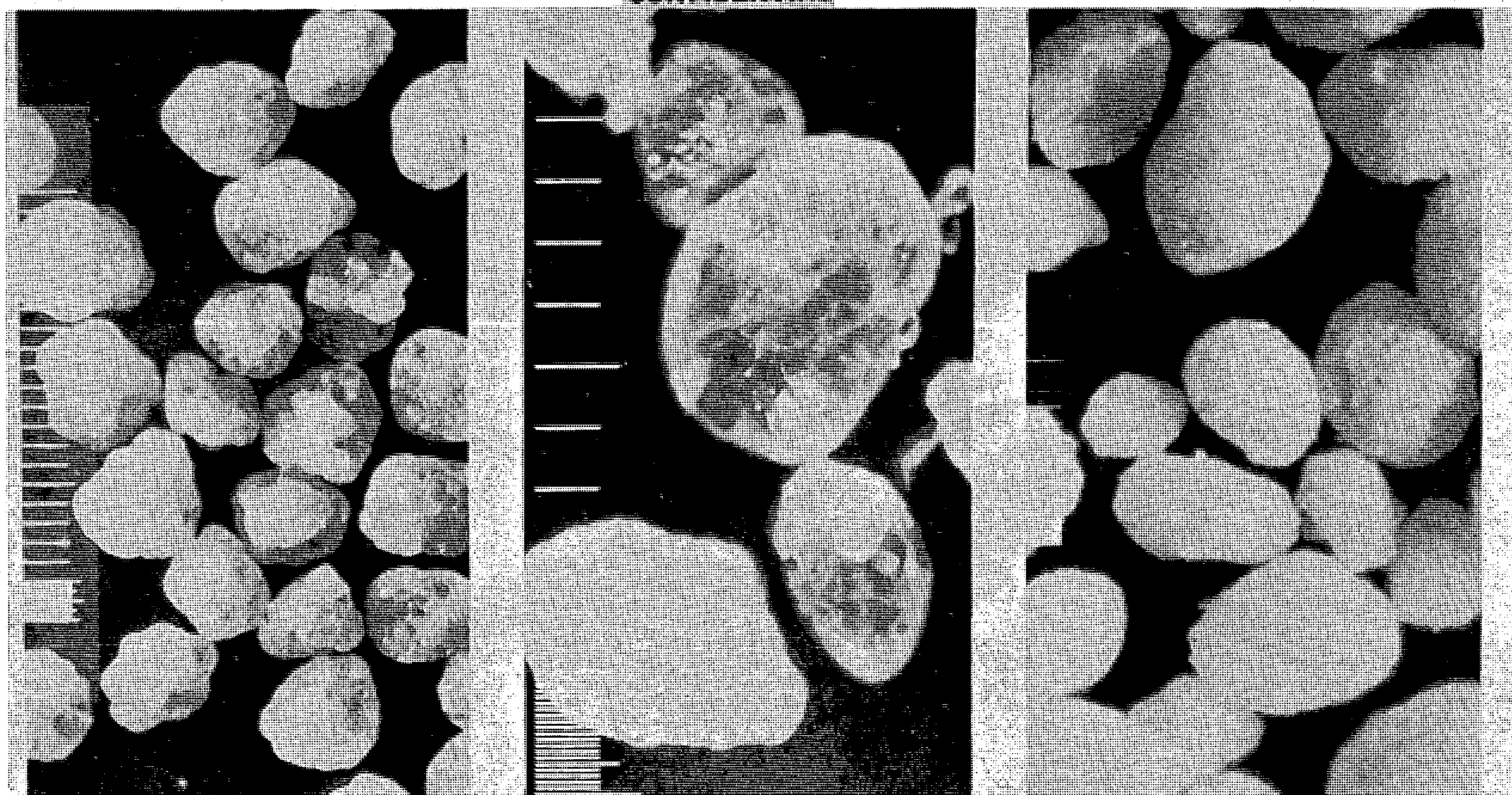

TETRYL 30x
Average Particle Size: 605 Microns

RDX 100x
Average Particle Size: 388 Microns

COMPOSITION A-3 20x
Average Particle Size: 862 Microns

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Figure 10

M-42162 March 1955 PICATINNY ARSENAL ORDNANCE CORPS
Project No. TA3-5002 Prepared by: A. M. Anzalone Scale: 0.1 mm, 0.01 mm.

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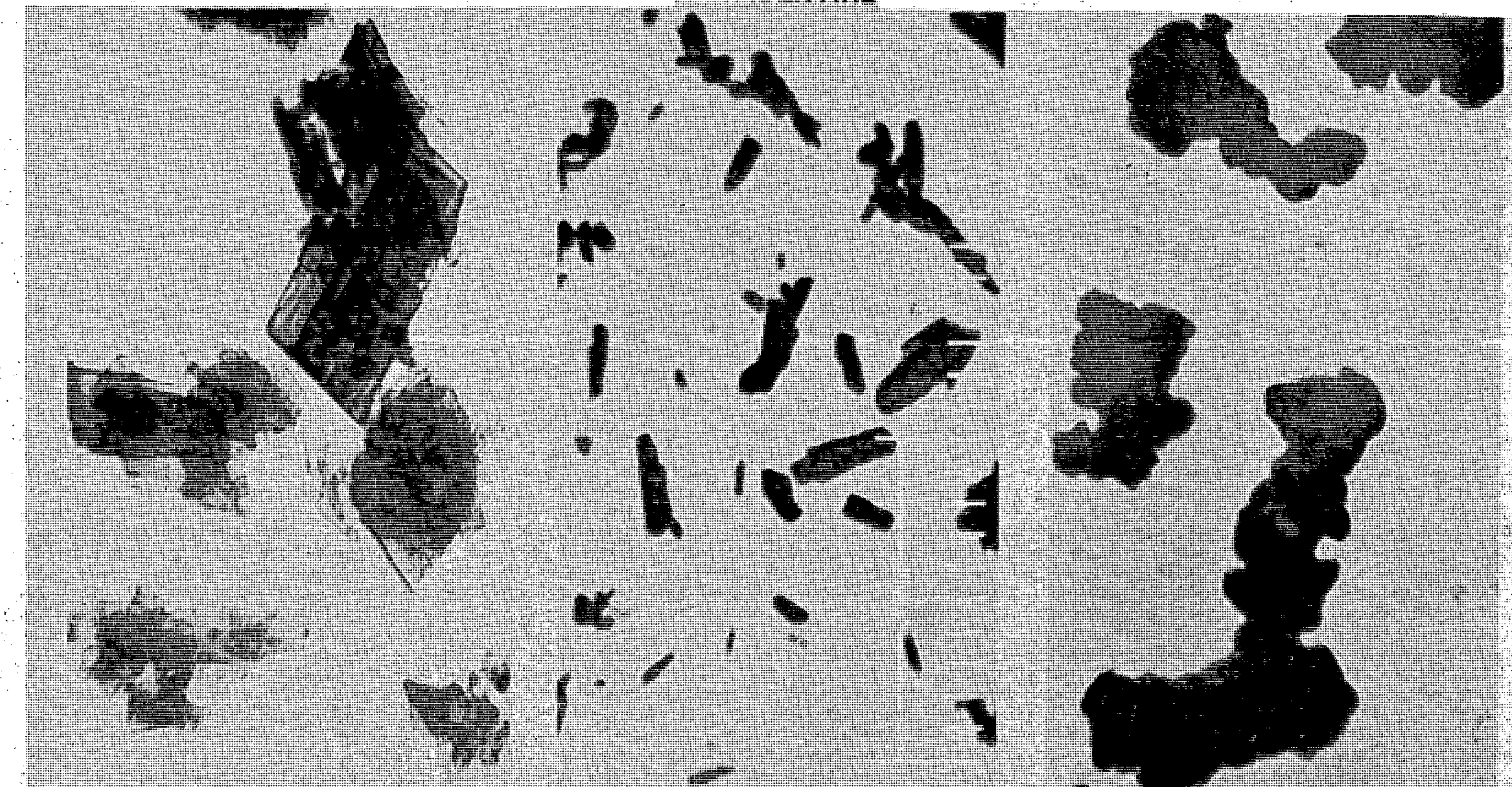

POTASSIUM DINITRO BENZO FUROXAN 450x
Average Particle Size: 74 Microns

DIAZO DINITROPHENOL 500x
Average Particle Size: 28 Microns

COMMERCIAL GRADE LEAD AZIDE 520x
Average Particle Size: Agglomerates

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Figure 11

M-42160 March 1955 PICATINNY ARSENAL ORDNANCE CORPS
Project No. TA3-5002 Prepared by: A. M. Anzalone Scale: 0.1 mm, 0.01 mm.

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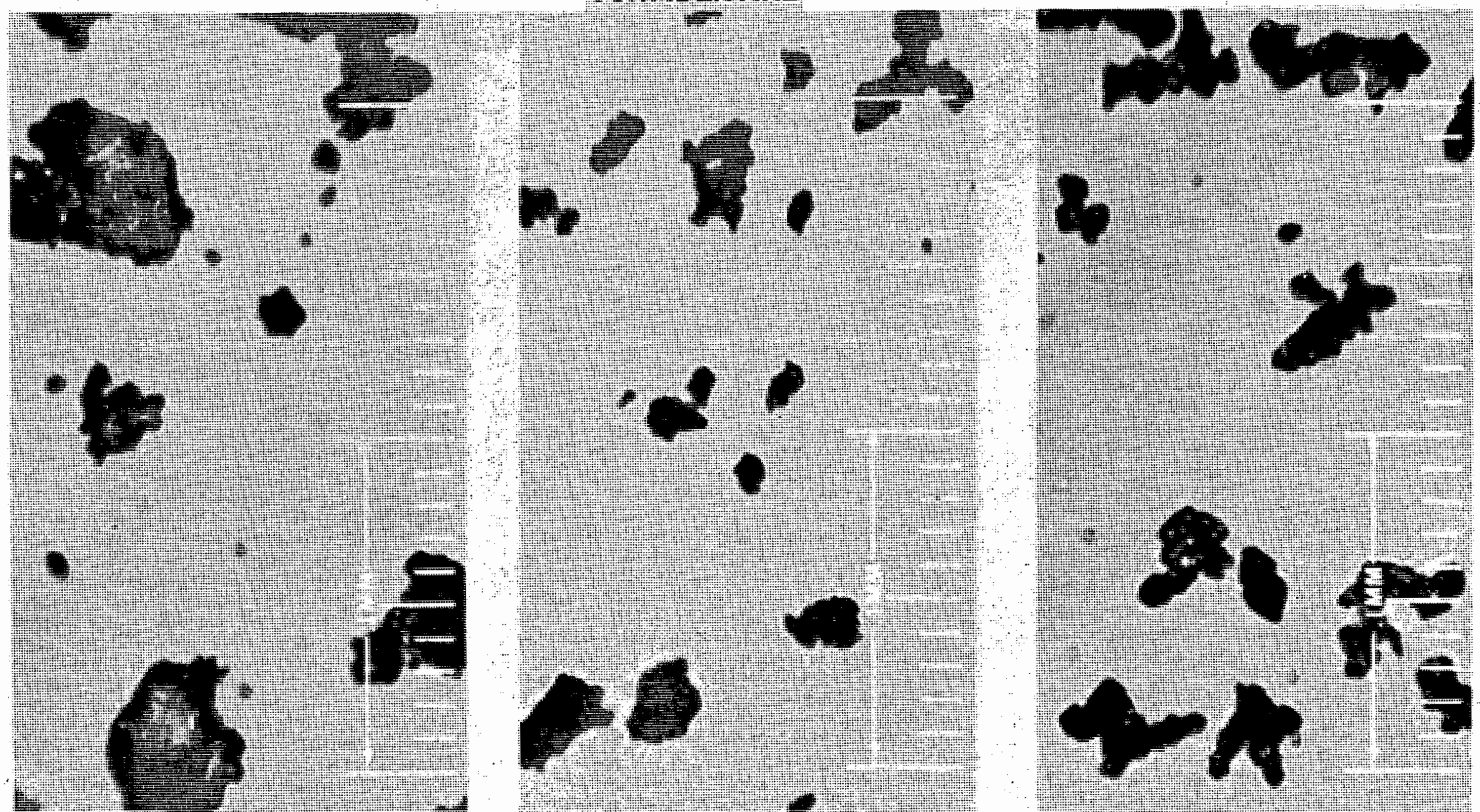


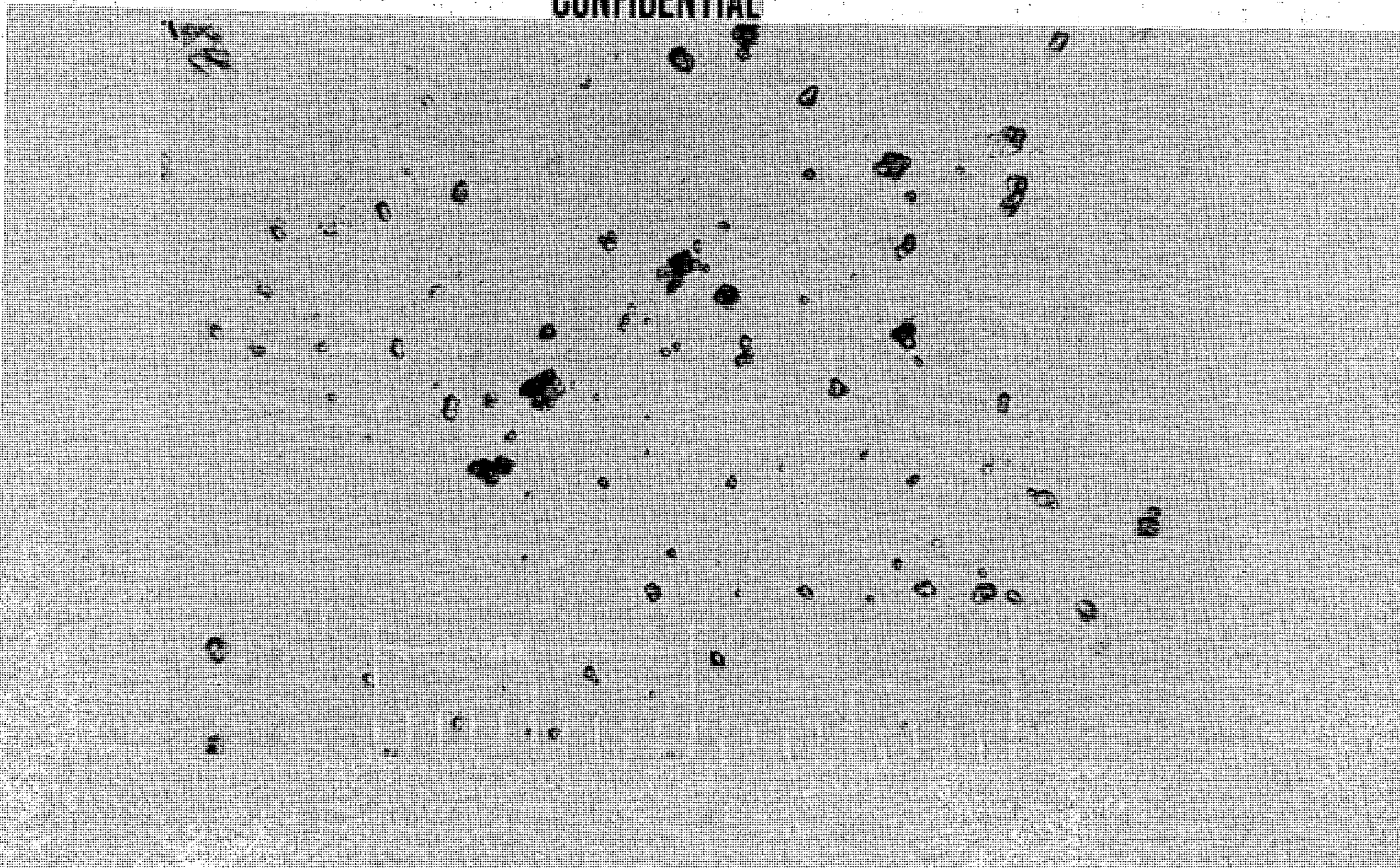
CUPROUS THIOCYANATE POTASSIUM CHLORATE 500x
Assorted Agglomerates

SILVER THIOCYANATE POTASSIUM CHLORATE 500x
Assorted Agglomerates

HEXAMINE CHROMIC PERCHLORATE 500x
Assorted Agglomerates

Figure 12

M-42161	March 1955	PICATINNY ARSENAL	ORDNANCE CORPS
Project No. TA3-5002	Prepared by: A. M. Anzalone		Scale: 0.1 mm, 0.01mm.



Copper Chlorotetrazole 500X

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Average Particle Size: ∠ 5 Microns

Figure 13

M-46412 March 1955 PICATINNY ARSENAL ORDNANCE CORPS

Project No. TA3-5002 Prepared by: A. M. Anzalone Scale: 0.1 mm, 0.01 mm.